THE DEVELOPMENT OF ALGORITHMS FOR ON-DEMAND MAP EDITING FOR INTERNET AND MOBILE USERS WITH GML AND SVG

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Commission VI, PS WG IV/2

KEY WORDS: Spatial Information Sciences, GIS, Research, Internet, Interoperability

ABSTRACT:

The widespread availability of the World Wide Web has led to a rapid increase in the amount of data accessing, sharing and disseminating that gives the opportunities for delivering maps over the Internet as well as small mobile devices. In GIS industry, many vendors or companies have produced their own web map products which have their own version, data model and proprietary data formats without standardization. Such problem has long been an issue. Therefore, Geographic Markup Language (GML) was designed to provide solutions. GML is an XML grammar written in XML Schema for the modelling, transport, and storage of geographic information including both spatial and non-spatial properties of geographic features. GML is developed by Open GIS Consortium in order to promote spatial data interoperability and open standard.

Since GML is still a newly developed standard, this promising research field provides a standardized method to integrate web-based mapping information in terms of data modelling, spatial data representation mechanism and graphic presentation. As GML is not for data display, SVG is an ideal vector graphic for displaying geographic data. GML sets at the back-end to store and transport data meanwhile SVG sets on front-end to render and display geographic data. The technology does not only enable the visualization of geographic data on the web, but also gives the possibility to edit geographic data online, especially via Internet and wireless environment in which GML gives a significant improvement of bandwidth, speed, access and reliability. Since both GML and SVG is text-based and vector format, it is expected that downloads can be considerably shortened and even more important for bandwidth can be substantially improved.

This paper therefore seeks to investigate the capability of GML and develop a corresponding data modelling, system and prototype in order to overcome or improve the existing limitation on GIS functions. Further discussion also emphasizes on online map editing function which is still not well developed over existing web mapping system.

1. INTRODUCTION

The widespread availability of World Wide Web gives the opportunities for delivering maps over the Internet as well as small mobile devices. The sharing of spatial data through Internet is important to promote interoperability of spatial data. Interoperability implies that there is some common concept on which information exchange and integration is based. (Vckovski, 1999)

Currently, there were over 30 different Web mapping software packages or solutions provided by different GIS vendors. Most popular Web Mapping packages are ESRI ArcIMS, Autodesk MapGuide, GeoMedia WebMap server, and MapInfo MapXtreme (Peng, Z. R. and Tsou, M. H., 2003). They all have their own proprietary data formats and different customized programming languages. Some of them render images such as GIF and JPEG but these raster data cannot be selected, changed styling or zoomed in for more detail. In term of vector data, different data formats restrict the integration of data for applications and analyses. Moreover, different data formats support different spatial models. For instance, a particular GIS format support complex spatial model whereas another merely support simple feature model. It is difficult to share data between disparate Internet systems over a wide area network.

On application level, the proprietary Web mapping applications are limited to their own corporate networks and developing languages. The vendor-based on-line spatial services and clients means that systems are neither interoperating with systems on the data level, nor the application level.

On functional level, most Web mapping software packages can perform simple GIS functions such as zooming, querying, selecting, buffering and styling. They seldom perform more advanced GIS functions such as spatial analysis and spatial editing. In existing market, two Web mapping software packages, ArcIMS and Autodesk MapGuide, offer GIS functions which are closed to editing capability on spatial data. The ArcIMS Java Viewer using feature services has two functions called MapNotes and EditNotes. The MapNotes function enables users to add text or graphics to the map. These edits are then sent to the MapNotes folder on the ArcIMS Server. The EditNotes function enables users to edit features on the displayed map. Similar to MapNotes, once users finish editing, the changes will be submitted to the EditNotes folder on the ArcIMS Server for the server administrator to review. EditNotes must be converted to shapefiles or XML. MapNotes and EditNotes are therefore just graphics on map but not edited features on the server (Alex, F., 2002).

For Autodesk MapGuide, functions are extended to include edit capability by the SDF COM Toolkit to enable users to create, edit, or delete actual SDF files. From the client end, the use of a MapGuide server requires downloading and installing a proprietary plug-in. Data are in proprietary format not readily accessible to or useable by other applications.

In short, over the Internet, it is essential to have a method of storing and representing data in an open, extendable and flexible way, but also in a way that is vendor-independent.

Therefore Geography Markup Language (GML) was designed to help solve above problems and promote interoperability of spatial data. GML is an XML grammar written in XML Schema for the modelling, transport, and storage of geographic information including both spatial and non-spatial properties of geographic features (OGC, 2003). It is developed by Open GIS Consortium in order to promote spatial data interoperability and open standard. It is specially designed for Internet mapping which has the potential to change how people share mapping information through Internet.

GML upholds the principle of separating geographic contents from its presentation. This offers more flexibility in data production, handling as well as visualization. GML is used as the standard of data exchange and then can be transformed into vector format such as SVG for graphic visualization so that downloads can be considerably shortened and even more important for bandwidth is the scalability inherent to vector lines. Once on the client browser, vectors are scalable without return trips to the server (Randy, 2002). The performance hence can be improved. It is essential for Web mapping which requires fast delivery time and high performance. It seems that GML and SVG are ideal for transporting and storing geographic information over Internet using advanced XML technology and provide potential capability to integrate different geographic information together.

The aim of this paper is to investigate and develop methods for generalizing map online and editing vector-formatted geospatial data to Internet and mobile user using emerging standards – GML and SVG. The main purposes are:

1   To develop method and usage practices for generalizing the graphic representation for geospatial data in real-time.
2   To develop data model and algorithms for testing the ability of editing data online.
3   To build a prototype to demonstrate the effectiveness of the proposed framework.

2. BASIC CONCEPTS

2.1 Geographic data in GML

GML is an XML based encoding standard for geographic information developed by the OpenGIS Consortium (OGC). GML 1.0 was released as a Recommendation Paper in February, 2001 and GML 2.0 was approved in April 2000 as an OpenGIS Implementation Specification. GML 2.0 provides for XML Schema, complex features and feature relations, extending GML's scope beyond the basic 2-dimensional vector-based descriptions in Simple Features. Currently, the latest version of GML is GML 3.0 which has been approved in January 2003. New additions in GML 3.0 support complex geometries, spatial and temporal reference systems, topology, units of measure,

metadata, gridded data, and default styles for feature and coverage visualization (OGC, 2003).

The overriding goad behind the implementation of GML was providing a means for the transport and storage of geographic information, which includes both spatial and non-spatial properties of geographic features especially in Internet environment. Characteristics of GML are as following:

Text-based, Open and Extensible: GML documents are text based and extensible. They can be easily edited, maintained and updated by any world processor. They can readily integrate geospatial data with other data types such as text, voice, graphics and video etc. Since relationships in XML elements are expressed in terms of parents and children, GML is extensible to define the content inside the elements.

Encoding Feature Geometry and Properties: GML is based on the abstract model of geography developed by OGC. The model describes the world in terms of geographic entities called features. A geographic feature is "an abstraction of a real world phenomenon; it is a geographic feature if it is associated with a location relative to the Earth" (OGC, 2003). A feature consists of properties and geometries. Properties include usual name, type, value description. Geometries are composed of basic geometry building blocks such as points, lines, curves, surfaces and polygons. In the latest version, GML 3.0 is extended to support 3D geometry and topological relationships also. It works closely to the features supported by common GIS data formats.

Transporting geospatial data over the Web: When the GML-coded geospatial data are transported, all markup elements that describe all spatial and nonspatial features, geometry, and spatial reference systems of the data are also transported to the recipient. So information will not get lost and distorted in the process of data transport and transformation. It is important for real time data access and transport in the Internet Environment (Peng, Z. R. and Tsou, M. H., 2003).

Separating content from data display: GML is not a presentation language for data display. It is different from other GIS data formats, which separates content from data presentation. Like XML, GML can be transformed into other vector graphics formats such as SVG for data display. The common style engines are XSL, XSLT and CSS. This allows different styles applied in the same GML documents.

Not a programming language for data processing: Like XML and HTML, GML is only markup language, not a programming language. GIS functions such as buffer analysis, spatial overlay, image processing and network analysis can be done with the aid of other programming languages such as C++, Visual Basic, Javascript or Java. Some other XML-based technologies like XSL, XSLT, Xpath and XML Query Language can also help to do GML data query and manipulation.

2.2 GML data visualization in SVG

Most of graphics on the Web are represented as images with a sequence of colored pixels such as GIF (Graphics Interchange Format), JPEG (Joint Photographic Experts Group) and PNG (Portable Network Graphics). An alternative approach is sending instructions for drawing features like lines or curves, which offers great advantages over pixel based formats. Nowadays, a number of vector formats are being used on the

Web e.g. Flash, Precision Graphics Markup Language (PGML), Virtual Reality Markup Language (VRML) and Web Compute Graphic Metafile (WebCGM). However, there was no widely standard format supported by the tools for creating Web pages. W3C therefore developed a new standard format for two dimensional vector graphics, SVG that matches the needs of content providers and browsers like.

SVG is an ideal candidate for displaying GIS information in a Web browser. All typical GIS features can be readily displayed and manipulated, and data are transferred in a compact vector format rather than raster format. SVG knows shape types for 2D graphics including rectangles, circles, ellipses, lines, polylines, polygons, symbols and path elements as shown in figure 1. These graphical objects can be grouped, styled and transformed using stylesheets such as XSLT and CSS. SVG is already supported by several browsers, but it still requires a plug-in for current versions of Microsoft Internet Explorer and Netscape. Adobe offers a free SVG plug-in called Adobe SVG viewer 3.0.
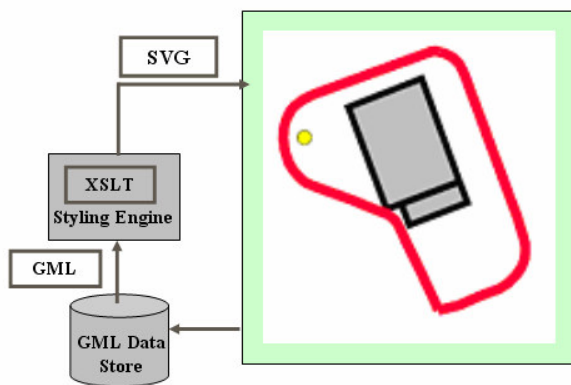

Figure 1 Relationship between GML and SVG

3. METHODOLOGY FOR IMPLEMENTATION

In order to test the editing capability of GML and SVG, we propose a framework. The major target of the framework is to design algorithms, mechanism and workflow of distributing geographic information online with more advanced editing functions. It focuses on examine specific problems and approaches in using SVG as a user interface for editing geographic data online.

3.1 Development of data model and design algorithms

GML has ability to provide a framework for modelling application relationships. This allows application to be designed independently yet still able to interoperate when using the same base object model (Toon, 2001). Application framework can depend upon one or more GML schemas by importing them shown in Figure 2. For example, schema 1 in the application framework imports the GML feature schema. Since this research will focus on mobile application, mobile GIS data model will be used. This research will based on existing mobile GIS data model developed by Kwan (2002) and will have further enhancement. Based on the model, the dynamic database was created to respond to the tasks from the mobile application. The contents in the dynamic database were automatically updated to reflect the situation of real world (Kwan, 2002). It is expected that further enhancements will be performed for the

model, for example, modeling the spatial relationship, modeling spatial entities and so on. Besides, the presented rules of mapping can be generalized easily to translate oriented objects models, in UML or another formalism, for files in XML Schema (Miguel and Cirano, 2002). The relationships between features and attributes in an application will be modelled by UML.

For graphic presentation, Scalable Vector Graphics (SVG) is applied. SVG is an XML grammar for describing 2D graphics. It includes elements for vector shape features, raster images, animation and text (Randy, 2002). GML is used as a spatial data interchange format, and SVG provides a format for viewing spatial data. As figure 2 shows that style engine will be used to transform GML data into SVG graphics. The figure summarizes the work flow of data structure and transformation.
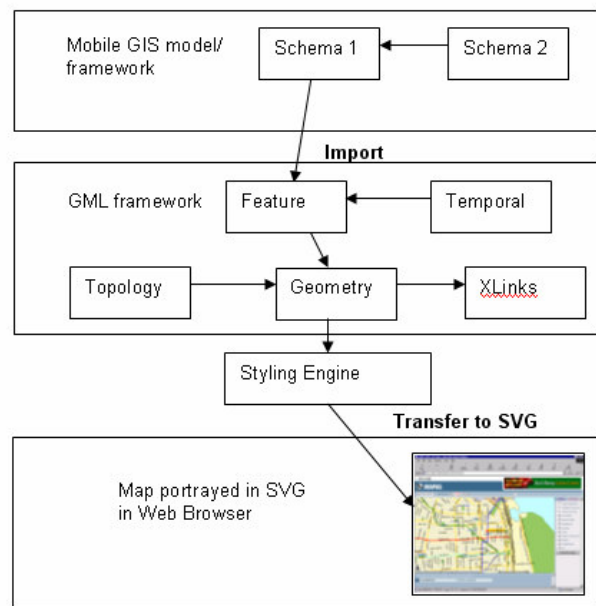

Figure 2 Overview of making vector maps on Web with GML

3.2 GML data Generation

To test the model, Hong Kong digital base map was collected from Land Information Centre (LIC) of Survey & Mapping Office, Lands Department for the framework. Scale 1:1000 digital topographic map (B1000) are used. Since the native format of the digital base map is in ArcInfo coverage format, data conversion from coverage format to GML data is required. The procedure of generating GML data is shown in figure 3.
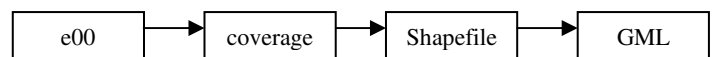

Figure 3 The data conversion process of generating GML data

The e00 files are the export format of ArcInfo coverage. They are first decompressed to ArcInfo coverage and then converted to shapefiles format. The reason of converting shapefiles is that many free tools are available to convert shapefiles to GML such as deegree command line shape to GML converter 1.5 (http://deegree.sourceforge.net/) By using free converter, shapefiles format data can be converted to GML data.

3.3 Application Schema Generation

Since Hong Kong base map has own specification of data content, an application schema specified for Hong Kong base map data is needed to validate the GML documents. Referring to the data dictionary of Hong Kong digital base map, an application schema declares actual feature types and property types. It defines data types of textual data. For example, it defines whether id should be in numeric and name should be string. It will be further developed to include schemas for different features such as building, road and contour etc.

3.4 XSL stylesheet Generation

In order to visualize GML data, stylesheets are required. As mentioned in previous section, stylesheets are used to convert and format GML into SVG and different style and symbols can be applied. A set of recommended styles and symbols for the portrayal of OS MasterMap data are specified. Since the Hong Kong digital map has own style and symbols in representing geographic features, a XSL stylesheet is need to be specially designed.

3.5 Design algorithms for editing function

SVG offers more than vector display. SVG document can be added, moved, modified, copied and deleted using client triggered graphical user interface (GUI) events (Randy, 2002). By developing some common scripting language like Javascript, the program can track the mouse and transform the user coordinate on client machine to the user-defined coordinate system. This makes onscreen digitizing online possible and then allows adding and updating data. The functions will include move, add and delete feature and vertex and modify textual information. In order to design and implement on-line editing capability using GML and SVG, a system will be set up. The basic algorithms and workflow of enabling data editing is shown in figure 4.
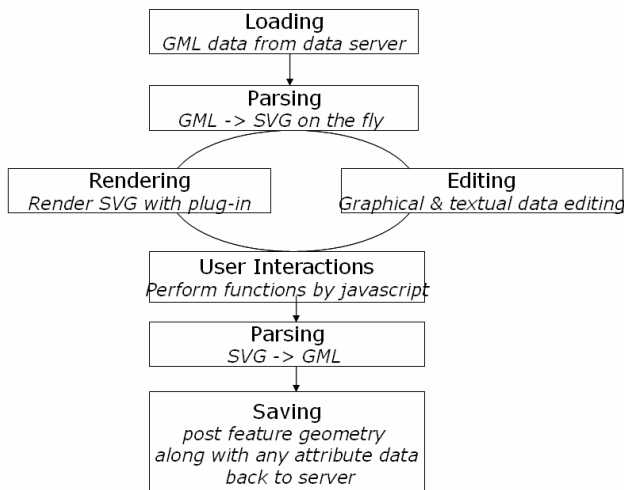

Figure 4 The basic workflow of data editing using GML and SVG

3.6 Development and evaluation of a prototype

After all, a prototype will be developed for testing the proposed data model and algorithms and applied for real application. The implementation will apply Java script and SVG DOM to make XML application and Web service. Since applications on Window CE platform become popular and increasingly gain market share (Legard, 2002), Window CE platform is chosen for evaluation. There are several components in the system including Web and data server, networking devices and mobile devices such as tablet and pocket PC.

1   A server which is capable of storing data and retrieving existing feature as well as carrying out update, insert, and delete requests on spatial and non-spatial attributes.
2   Protocols like Web service for transmitting data requests between client and server.
3   A client like internet browser or mobile devices which is capable of displaying spatial geometries and attribute information and allowing interactive input and editing.

In order to produce the application which can be applied in Hong Kong, Hong Kong base map data and networking data will be used and stored in database. The following Figure 5 is the overview of the proposed system.
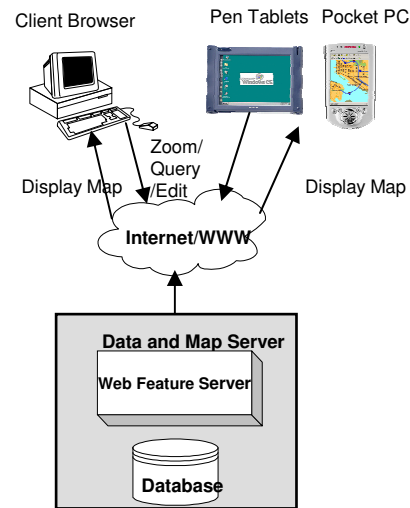

Figure 5 The overview of the proposed system for the prototype

The prototype will be used to demonstrate and test the effectiveness of the proposed data model and algorithms using existing GIS data. The data will be stored in database and served through Internet or wireless terminals. As both SVG and GML are XML-based, and conversion from one to the other is simple, GML could be used to handle GIS data and SVG to view and deliver it to mobile users, making one the perfect complement to the other.

Several functions including map rendering, spatial query, and map editing will be performed. GML and SVG will be served as vector format across the Internet. Data will be transferred as vector on the client browser. The browsers allow users to control their view with zoom and pan the same way they do so in GIS software. For example, when the user wants to zoom or pan to a different area of the map, that request is then sent back to the GML data store, where the Web feature server will extract new GML features and send them the style engine for styling. The styled SVG will send to the Web for display again. SVG links can also trigger server events to query database.

For implementation, many free tools are available now. One of advanced tools for distributing GML and SVG data is the GeoServer project which is the open Internet gateway for geographic data (http://geoserver.sourceforge.net). GeoClient, which is a part of the GeoServer project, is graphical software for online mapping. GeoClient is designed to work as a client to a server operating on the Open GIS Consortium's Web Feature Server standard. It is written in Scaleable Vector Graphics (SVG) and ECMAscript/JavaScript. Some basic functions of map interface are available such as zooming, panning, querying and identifying attributes. The prototype will be based on the tool of GeoServer and GeoClient to be further developed and customized. Figure 6 shows the SVG Web map using Hong Kong base map data.
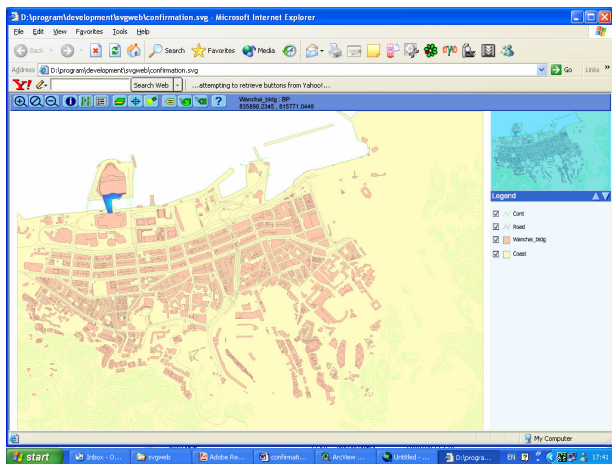

Figure 6 The interface of SVG Web map using Hong Kong base map data.

The possibility of editing data through Internet will be tested. For example, people can digitize the route of their truck by mobile devices. With this function, people can edit and get real time information anytime, anywhere.

4. CONCLUSIONS

The paper describes an ongoing project and addresses the new idea of deploying GIS data through Internet with open and standard application and design algorithms for online data editing capability. The framework is based on open and non-proprietary standard, which provide ideas of distributing GIS data and application in Hong Kong by using open and standard way.

We have proposed a framework for integrating distributed Web-based GISs by using GML and SVG technologies. The study of generating GML, GML schema, XSL stylesheets and SVG, the methodology of the framework has been examined and developed.

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